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SEISMIC ARRAY ANALYSIS CENTER FINAL REPORT, JANUARY 1972-JUNE 1973

William C. Dean

Teledyne Geotech

Prepared for:

Advanced Research Projects Agency
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SEISMIC ARRAY ANALYSIS CENTER
FINAL REPORT

January 1972 through June 1973

18 October 1973

AFTAC Project	VELA T/2709
Project Title:	Seismic Array Analysis Center
ARPA Order No.:	1620
ARPA Program Code No.:	2F10
Name of Contractor:	TELEDYNE GEOTECH
Contract No.:	F33657-72-C-0471
Effective Date of Contract:	1 January 1972
Amount of Contract:	$1,663,848
Contract Expiration Date:	30 June 1973
Project Manager:	William C. Dean (703) 836-3882

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TABLE OF CONTENTS

INTRODUCTION

This final report summarizes the operation, results, and published evaluation reports of the Seismic Array Analysis Center (SAAC), under the contract F33657-72-C-0471, for the period starting 1 January 1972 and ending 30 June 1973. The operational procedures followed were similar to those followed by Teledyne Geotech under contract F33657-71-0510. The work statement for this contract is given in Appendix I.

CONTRACT TASKS

a). Operations

During the 18 months from 1 January 1972 to 30 June 1973 we have operated the SAAC automated data acquisition and processing systems as developed by the Federal Systems Division of IBM under contracts F19628-67-C-0198 and F19628-68-C-0400. It was the latest version of the IBM-SAAC program, the Integrated Seismic Research Signal Processing System (ISRSPS), which we operated routinely 24 hours per day, seven days per week throughout the contract duration.

The ISRSPS programs operated in two parts. The Detection Processor (DP) performs data acquisition and signal detection. The Event Processor (EP) is designed to recognize true signals and false alarms and to extract event parameters, refine locations, and publish an earthquake bulletin. The Event Processor is programmed to work either in an automated mode in which the computer analyzes events and publishes the bulletin without help from a seismic analyst, or to act as an aide to the analyst who can edit the event processing on a display console.

Table I shows the DP uptime and downtime and the percent of time the system was down due to hardware, software, power, 50 kilobit data line failures, and preventative maintenance. The total uptime throughout this period was 95.2%.

	QUARTER							
	1972				1973			
	1st	2nd	3rd	4th	5th	6th	Total	Percent
Problems								
Hardware	44.2	115.1	13.4	9.2	24.5	20.6	227.0	1.7%
Software & Testing	6.5	13.7	5.2	30.3	6.6	0.0	62.3	.5%
Power Failure	7.3	12.2	4.2	2.0	3.2	6.0	34.9	.3%
50 KB Line	56.2	34.6	19.0	58.0	8.1	53.7	229.6	1.7%
Preventative Maint.	12.8	12.4	10.3	12.3	10.5	19.1	77.4	.6%
Total DP Downtime	127.0	188.0	52.1	111.8	52.9	99.4	631.2	4.8%
Total DP Uptime	2057.0	1996.0	2155.9	2096.2	2107.1	2084.6	12496.8	95.2%
Total Possible	2184.0	2184.0	2208.0	2208.0	2160.0	2184.0	13128.0	100.0%
Percent Uptime	94%	91.3%	97.5%	94.8%	97.5%	95.3%	95.2%	

Table I. DP ISRSPS Up/Downtime in hours for LASA Data from 1 January 1972 through 30 June 1973

Table II shows the number of events listed on the LASA daily summary for each quarter throughout the 18 months of the contract. In addition the table shows the number of detections for each quarter with the DP threshold set at 10db.

Table II also lists the number of hours of data processed for EP for each quarter and the amount of time spent by the analyst at the display console (EOC), to analyze these events.

The LASA Daily Summary was published and distributed to a list of recipients approved by the project officer throughout the contract (see Appendix C). In addition the Daily Summaries were compiled into a LASA Weekly Summary and mailed to a wider list of recipients approved by the project officer (see Appendix D).

We have operated and maintained all on-line and off-line GFE computers and other associated equipment on a 24-hour per day, seven day per week schedule, including the IBM 360/44 research computer and its associated peripherals. We have also recorded on a 24-hour, seven day a week schedule both short period and long period data from the Large Aperature Seismic Array in Montana (LASA), the long period data from the Alaskan Long Period Array (ALPA), and the long period plus selected short period data from the Norwegian Seismic Array (NORSAR) received over the Trans-Atlantic Link (TAL) in accordance with contract requirements.

Quarter	1972 1st	1972 2nd	1972 3rd	1972 4th	1973 5th	1973 6th	Total
DP Recording Time covered by EP Analysis	2053.3	1968.9	2147.1	2095.7	2102.6	2074.2	12441.8
Analyst Time Required on EOC	368.5	438.6	311.1	318.9	310.6	325.8	2073.5
IBM 360/40B Time Required on EP	1379 6	936.3	820.4	997.8	1058.9	985.1	6178.1
Number of Detections	42651	40012	41860	43110	47836	42777	258246
Number of Events Listed on Summary	2048	2035	1967	2110	2045	2444	12649

Table II. DP EP Analysis Time in hours for LASA Data from 1 January 1972 through 30 June 1973

We have maintained the documentation for the ISRSPS-DP, EP, and support programs throughout the contract. Much of the documentation for the system changes and new programming efforts has been completed. However, small updates to the ISRSPS manuals 101S, 102S, 113S, 110S, and 111S are needed to bring them current to the end of the contract. This effort is currently underway. We have printed and issued a SDAC Operation Reference Book to assist operators with procedures for the ISRSPS system and the batch machine. This is a supplement to ISRSPS Reference Program Manual 113S.

We have provided technical support and computer services for personnel of Texas Instruments, Inc., (TI), on Project VT/1705, contract F33657-71-C-0843 and its follow-on effort. Texas Instruments personnel have been authorized a maximum 25 percent of the IBM 360/44 computer time available. Throughout the SAAC contract they have utilized approximately 23.8 percent of the available IBM 360/44 computer time. Similar services were provided to IBM personnel on contract F19628-68-C-0400 through 31 August 1972.

SAAC supplied seismic data to qualified outside users usually in response to requests which specify source, time interval and format. The principal user of this service is the MIT Lincoln Laboratory for which a total of 2969 requests were filled. In addition SAAC filled 333 requests from Texas Instruments and 155 from the Alexandria Laboratories.

Data processing requests were completed for the following: University of California at San Diego, 9; University of Texas at Dallas,8; and University of Hawaii, 7.

We have maintained the SAAC library of digital magnetic tapes throughout the contract. Table III lists digital magnetic tapes in various categories as of 30 June 1973.

b). Evaluation and Modifications to the SAAC Data Acquisition and Processing Systems

For evaluation of the LASA/SAAC system we continued its on-line operation and compared its output and system performance with the operation during the previous contract year. In addition we conducted a study to optimize system parameters by running previously recorded data with the off-line DP programs. System parameters were varied and the results compared to the performance of the on-line system. Reports on these subjects are in preparation.

This same procedure was used to study the effect of a reduction in number of sensors and number of subarrays at LASA.

Several sets of modifications were made to EP and DP programs during the contract. The purpose of the first set of modifications to the EP system in January 1972 was to upgrade the release of the operating system, correct some known errors, and

TABLE III

SAAC Magnetic Tape Library

Tape Assignment Total as of 30 June 1973

Permanent Retention:	Tapes
Event	499
Long Period	3306
Short Period	
LASA	2843
NORSAR	661
Detection log (International Seismic Month)	30
Extended Long Period (LPE)	503
Misc. (ALPA, LASA Backup Copies, etc.)	220
To Be Recycled:	
Short Period	8900
Detection Log	25
Individual Users	1247
Scratch Tapes	1636
Total Tapes	19,876

Retention Cycle:

Low Rate Long Period - Permanent
High Rate Tapes Short Period - One Year
Edited High Rate Tapes - Permanent
Event Tapes - Permanent
Detection log Tapes - One Month
System back-up, Seismicity File - Permanent
Scratch tapes - 48 Hours. (User may then request that the tape be saved for a fixed time period or permanently).

improve several operational difficulties that were observed during 1971. The operational improvements were accomplished by the addition of 10 new event data sets on disk, an enlargement of the Signal Arrival Queue on the DP-EP shared disk, the installation of an option which allows the operator to determine the EP work load, an improved beampacking algorithm, and the elimination of the computer publishing of the bulletin when the event data sets were full.

The second set of modifications to the on-line system consisted of changes in both DP and EP to provide the Norwegians with SAAC data. The system upgrading in May 1972 allowed the continuous transmission of data from SAAC to the Norwegian Data Processing Center associated with NORSAR. The data being transmitted includes LASA and ALPA LP data, the LASA/SAAC detection list, and the SAAC EP output.

Other modifications made to both EP and DP later in the contract year included refinements to operational procedures, adjustments to system load problems caused by the additional transmission of data to NORSAR, and general software error corrections.

In addition to the above, considerable programming effort was used to extend the capabilities of the off-line DP system. Changes were made in off-line DP and the associated parameter control programs to permit the user to vary the number of sensors per subarray and the number of subarrays.

Several ISRSPS support programs were developed to meet new requirements. They included a program which reads SAAC data tapes and produces the NORSAR bulletin, a program which reads the SAAC data tapes and produces a list of the NORSAR DP detections, and a set of programs which provides file maintenance and analysis information on SAAC events. The file maintenance programs were later expanded to maintain, and also provide a search capability for, other seismic event data as needed for research under both the SAAC and SDL contracts.

c). LASA and NORSAR Short-Period Processing

A study of short-period network processing techniques using LASA and NORSAR data is presented in SAAC Report No. 12, "A Comparison of the LASA-NORSAR Short Period Arrays", by A. C. Chang (in press).

d). Detection and Discrimination Capabilities of LASA, ALPA, and NORSAR

An evaluation of the Rayleigh wave detection thresholds for the LASA, ALPA, and NORSAR long-period arrays and their capabilities in explosion-earthquake discrimination utilizing the magnitude ratio of long-period surface waves (M_s) to body waves (m_b) is presented in SAAC Report No. 10, "Detection Threshold of the LASA, ALPA, NORSAR Long-Period Network", by H. Mack and H. C. Robertson (in press).

Two additional reports covered aspects of long-period array performance. SAAC Report No. 9, "FKCOMB, A Fast General Purpose Array Processor", by E. Smart, 20 December 1972, describes the array processing technique used in the analysis of the long-period detection thresholds at ALPA, LASA, and NORSAR. SAAC Report No. 8, "Spatial Coherence of Surface Waves", by H. Mack, 20 December 1972 describes the difference in coherency along the propagation path and normal to it for Love and Rayleigh waves recorded at LASA, ALPA, and NORSAR.

e). VSC-Approved R&D Experiments

A selected set of WWSSN stations were studied to determine their potential worth as a supplement to a monitoring network of arrays stations, to rank these stations in order of their potential worth to the network to recommend the necessary changes, and to estimate the associated costs for the upgrading. SAAC Report No. 11, "Study of Selected World-Wide Standard Seismograph Network Stations", by J. E. Fix, J. G. Swanson, and W. D. Ballard; 2 April 1973 presents the results of this study.

In July 1972 the 360/44 was augmented by the addition of 131,072 bytes of main memory giving a total of 393,216 bytes. Also the two IBM 2311 disk spindles were replaced by three CDC CD12 disk spindles giving a disk storage capabity of 43.5M bytes (6 times the original amount). The purpose of these changes

was to upgrade the 360/44 to increase throughput and, thus absorb the increase workload which resulted from the loss of the CDC 1604. These changes, together with the rental of the GRASP spooling system produces a throughput increase of approximately 25%.

In early 1972, SAAC personnel began a large effort of conversion of major application programs from the CDC 1604 computer to the IBM 360/44 computer system. This conversion effort consisted of:

1. The development of system support routines to replace analogous ones which existed on the CDC 1604.

2. A major upgrade of the SAAC plotting capability, which was accomplished partly by in-house programming and partly by the purchase of a CALCOMP's proprietary plot package.

3. A major upgrade of the file maintenance programs to replace that capability lost with the removal of the CDC 1604.

4. A support service to aid the many scientists, analysts and programmers involved in the conversion effort.

5. An upgrade of the 360/44 Disk Operating System to take advantage of the new hardware augmentation and produce an increase in the throughput of that computer system in an effort to offset the shut-down of the CDC 1604.

In June 1972, SAAC received the first of its ARPANET terminals including a Terminal Interface Message Processor (TIP) and two terminals, an ASR33 and a TI 725 teletype. Later, in July, the IMLAC PDS-1 graphics display unit was installed. This equipment provided SAAC with the capability of using the resources of the ARPA Network and to run the FKCOMB program on a large volume of long period seismic data on the IBM 360/91 at UCLA. In June 1973 the FKCOMB program was running successfully with seismic data stored on tape at UCLA.

In February 1973, a special HOST to TIP interface was installed which provided SAAC with a file transfer capability that will complement the interactive capability available from the TIP and its terminals. This file transfer capability enables SAAC to utilize the card reader, tapes, disks, and printer on the IBM 360/44 to transfer seismic data and processed output to and from computer centers on the ARPANET.

REFERENCES

Chang, A. C., SAAC Report No. 12, "A Comparison of the LASA-NORSAR Short Period Arrays", (in press), Alexandria Laboratory.

Fix, J. E., Swanson, J. G., and Ballard, W. D., SAAC Report No. 11, "Study of Selected World-Wide Standard Seismograph Network Stations", 2 April 1973, Alexandria Laboratory.

Mack, H., Robertson, H. C., SAAC Report No. 10, "Detection Threshold of the LASA, ALPA, NORSAR Long Period Network", (in press), Alexandria Laboratory.

Mack, H., SAAC Report No. 8, "Spatial Coherence of Surface Waves", 20 December 1972, Alexandria Laboratory.

Smart, E., SAAC Report No. 9, "FKCOMB, A Fast General Purpose Array Processor", 20 December 1972, Alexandria Laboratory.

APPENDIX A

STATEMENT OF WORK TO BE DONE

F33657-72-C-0471

APPENDIX A — ASD/SMK revised in accordance with Amendment 1 dated 8 October 1971

STATEMENT OF WORK TO BE DONE

(AFTAC Project Authorization No. VELA T/2709/B/ASD)

Tasks:

a. Operate the Seismic Array Analysis Center (SAAC) on a 24-hour-day, 7-day-week basis in accordance with Reference 113S, Integrated Seismic Research Signal Processing System Operating Manual, as amended. Included in this task are the following:

(1) Operate, maintain, and keep in serviceable condition all Government-furnished property (GFP) except IBM equipment listed in the IBM/GSA schedule.

(2) Record and store all incoming data from the three large research arrays: the Large Aperture Seismic Array (LASA), the Alaskan Long-Period Array (ALPA), and the Norwegian Seismic Array (NORSAR).

(3) Operate on-line short-period detection processor for LASA data.

(4) Operate on-line long-period processor and display selected ALPA data on GFP develocorders.

(5) Operate off-line long-period processor for determining event parameters of detections from the on-line detection processor.

(6) Operate the off-line research computer.

(7) Make recommendations for modification to equipment and on-line processors and effect such modifications as approved.

(8) Maintain and update all operational and maintenance manuals associated with the operation of the SAAC.

(9) Update and maintain digital computer programs developed or provided as GFP for use in the SAAC.

(10) Transmit technical, processed, recorded, and real-time data to users as scheduled or required. This will include reformatted NORSAR data provided as GFP.

(11) Provide technical support and computer services for up to 15 personnel of Texas Instruments, Inc., in residence at SAAC performing on Project VT/1705, Contract F33657-71-C-0843, and follow-on effort. Computer time provided will not be more than 25 percent of available IBM computer 360/44 time, averaged over a one-month period.

(12) Provide technical support and computer services to scientific investigators and Government representatives after coordination through the project officer.

(13) Publish the LASA daily event summary in format specified in the SAAC Quarterly Technical Summary Report, 12 Apr 1971.

(14) Provide technical support and computer services for up to 15 personnel of IBM in residence at SAAC performing on Contract F19628-68-C-0400 and follow-on effort. Provide this support through 31 Aug. 1972. Computer time provided will not be more than 120 hours per month of available IBM computer 360/44 time.

b. Evaluate and modify, after technical liaison with the project officer, the existing SAAC automated data acquisition and processing systems developed under Contract F19628-68-C-0400 and follow-on effort.

c. Investigate short-period network processing techniques using LASA and NORSAR data.

d. Evaluate the network detection and discrimination capability of the three arrays: LASA, ALPA, and NORSAR.

e. Provide up to 40 man-months of research effort directed toward the definition and performance of approved experiments identified by AFTAC/VELA Seismological Center.

APPENDIX B

TASK CHANGE PROPOSALS

APPENDIX B

TASK CHANGE PROPOSALS

The SAAC Contract, F33657-72-C-0471, was augmented by several Task Change Proposals (TCP's). The ones which increased the level of effort and changed the scope of the contract can be summarized as follows:

TCP-0001 - Additional programming to convert CDC-1604 computer programs to IBM 360/44 computer programs. Level of effort; 5630 man-hours.

TCP-0002 - Additional programming, analysis, and liaison to familiarize SAAC staff with the ARPANET, to interface with ARPANET personnel, and train the SAAC scientific staff on the use of the ARPANET facilities. Level of effort; 2000 man-hours.

TCP-0003 - Additional hardware to augment the capabilities of the IBM 360/44 computer. The additional hardware to include a 50% increase to main memory (or 128K bytes of core storage) plus a six-fold increase in the disk storage capacity.

TCP-0008 - Additional hardware to interface the IBM 360/44 computer and its peripherals to the ARPANET via the TIP plus additional programming to install a Network control Program for this interface.

APPENDIX C

DISTRIBUTION LIST FOR THE LASA DAILY SUMMARY

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DISTRIBUTION LIST FOR THE LASA DAILY SUMMARY

NOAA	Mr. James Lander 910-420-1212 (routed through TWX/TELEX Conversion)
Lincoln Lab	Dr. Richard T. Lacoss 710-348-0414
VSC	Delivered by hand
AFTAC	510-958-2197
ARPANET (USC)	Hard-wired to TIP Address Procedure - Type Out: HOST 86 USER I.D. (SAAC-USER) PASSWORD

APPENDIX D

DISTRIBUTION LIST FOR LASA WEEKLY SUMMARY

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DISTRIBUTION LIST FOR LASA WEEKLY SUMMARY

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